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An overview of surface wave methods and a reliability study of a simplified inversion technique

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ABSTRACT

Following a brief overview of the history and the development of the Surface Wave Method—with a focus on techniques for processing and inverting field data—a Simplified Inversion Method (SIM) is described, which constitutes an improvement of the Satoh et al. (1991) [1] method. The SIM is a direct inversion method of surface wave dispersion data, making use of a penetration depth coefficient, a_R, whose value is a function of Poisson's ratio and the overall shape of the dispersion curve. In the present study the coefficient a_R has been evaluated using data from (a) an extensive database compiled from the technical literature and containing results of inverted surface wave measurements and nearby cross-hole/down-hole measurements, (b) results of side by side surface wave and cross-hole measurements, performed at five sites in the course of this study, (c) finite element analyses simulating the performance of surface wave measurements and thus providing "virtual" data, and (d) applying a current advanced inversion code, available on the Web. Based on all the above data, optimum values of a_R (and of the corresponding uncertainty of the derived V_{so} vs. depth profile) have been estimated. These values were found to be independent of depth from ground surface. The results of all analyses and comparisons indicate that for the majority of realistic soil profiles (including cases of normal and inverse dispersion conditions) the proposed SIM provides very reliable V_{so} vs. depth profiles when a value of a_R=0.63–0.67 is used in the inversion process. It is concluded that the SIM can be used with confidence as a direct inversion method of surface wave dispersion data.

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1. Introduction

The propagation of surface waves generated by seismic events in the vicinity of the Earth's surface was first utilized in the 1920s on a regional (or geophysical) scale for estimating the Earth's properties [3]. During the next few decades the method was gradually extended to the geotechnical engineering scale for the geotechnical characterization of near-surface soil formations, using either artificially generated or naturally occurring ground surface vibrations (microtremor). The method is presently known as Surface Wave Method (SWM) and has evolved into a powerful tool that is widely utilized in the subsurface geotechnical and geophysical explorations, for estimating $V_{s,30}$ [4] and seismic site response [5].

The scope of the present study is to first present a brief overview of the surface wave methods used for geotechnical site characterization, putting the emphasis on the construction of a dispersion curve and on its inversion for the evaluation of V_{so} vs. depth variation. Following this overview, a simplified direct inversion method (SIM) is presented [6,7], which is an extension of a method proposed by Satoh et al. [1]. The reliability of SIM is examined through comparisons with a database of published cases including dispersion curves inverted by advanced methods as well as results of cross-hole or down-hole measurements in the vicinity of surface wave measurements. Additional reliability estimates of the proposed inversion method were performed using (a) numerically simulated (i.e. virtual) SASW results and (b) direct comparisons with a current advanced method of inversion. All comparisons demonstrate the reliability of SIM and its use is proposed either for directly inverting surface wave data or for constructing the starting soil model in advanced automated inversion techniques. A Visual Basic software has been written for the rapid processing of wave dispersion data.

2. Surface wave methods (SWM)

2.1. Data acquisition and construction of dispersion curve

The first surface wave method (SWM) for geotechnical site characterization was developed in Germany in the decade of the

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